

SPECIFICATION

LH2000

M985

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AUTHORS

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DEPARTMENT

AFRD

DATE

8/28/200

HTS Current Lead Splice Procedure
6-14-02

Purpose: This procedure shall be used by the Cryogenic Feed Box vendor to insure that the splices are prepared in a reproducible, consistent process. This procedure will result in splices that have the required electrical and mechanical properties. In service, the joints will be submersed in liquid helium and will operate at currents up to 7500 A.

Materials:

1. The solder shall be Sn96.5Ag3.5, with a melting point of 221 C. Two types will be required: ribbon manufactured especially for this application (Dwg. No. 5520-MA-369904), and wire (Kester Sn 96 or equivalent).
2. The solder flux shall be chloride-free rosin type (Kester 135 or equivalent).
3. Copper cable, designation LHC-3C-NCU03, to be supplied by LBNL.
4. Superconductor cable, type LHC-3, to be supplied by LBNL.
5. Cartridge heaters (Watlow Firerod 9813 J3A112 L12) Wire with 120 VAC standard power plug.
6. Thermocouples and readout instrumentation
7. Excess solder/flux catch basin.
8. Disposable flux brushes.
9. Isopropyl alcohol
10. Paper wipes
11. Scotchbrite abrasive pads

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Parts and Drawings:

1. Solder boxes (Dwg. # 25I6664) shall be OFHC copper.
2. Solder box mounting plates (Dwgs. # 25I6633 & # 25I6703)
3. NEMA G10-CR push blocks (Dwg. # 25I6683)
4. Aluminum push block (Dwg. # 25I6673)
5. NEMA G-10CR clamping plates (Dwg. # 25I6643)

Specifications. The specifications required for this procedure are:

1. MSDS No. 135—for Kester Type 135 rosin soldering flux.
2. ASTM B32-89 (Sn96.5Ag3.5 Solder).
3. CDA 101--oxygen-free copper
4. LHC IR Quadrupole Inner Layer Cable, type LHC-3.

Lead cable description and handling notes:

Four different cables are used in the 7500A lead splices. Two cables are connected to the HTS leads, and are both copper/superconductor composites. The other two cables are connected to the lambda plate; one is a copper/superconductor composite and the other is pure copper. Note: the lambda plug also contains 24 smaller cables that will be treated in a separate procedure.

The pure copper cable is always on the bottom (Dwg. #25I495). Note: although the cables may appear to be rectangular in cross section, they are actually trapezoidal in cross section. Thus, they must be assembled correctly in order to avoid tilting in the soldering fixture. Finally, the cables have limited flexibility in a “hard way” bend, and over-bending will result in decabbling.

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Splice procedure

1. Install the solder box (DWG # 25I6664), mounting plates (DWG # 25I6633, 25I6703), Nema G10 Push Block (DWG # 25I6683) and clamp Plate (DWG #25I6643) into the LHC IR Feed box. Refer to Photo #1. It should be noted that there are two distinct mounting plates, one eight inches in length and one ten inches in length. Install appropriate mounting plate into appropriate spot in the LHC IR feed box according to the rib spacing. Refer to drawings 25I6854 and 25I6694 for assembly hardware and bill of materials.

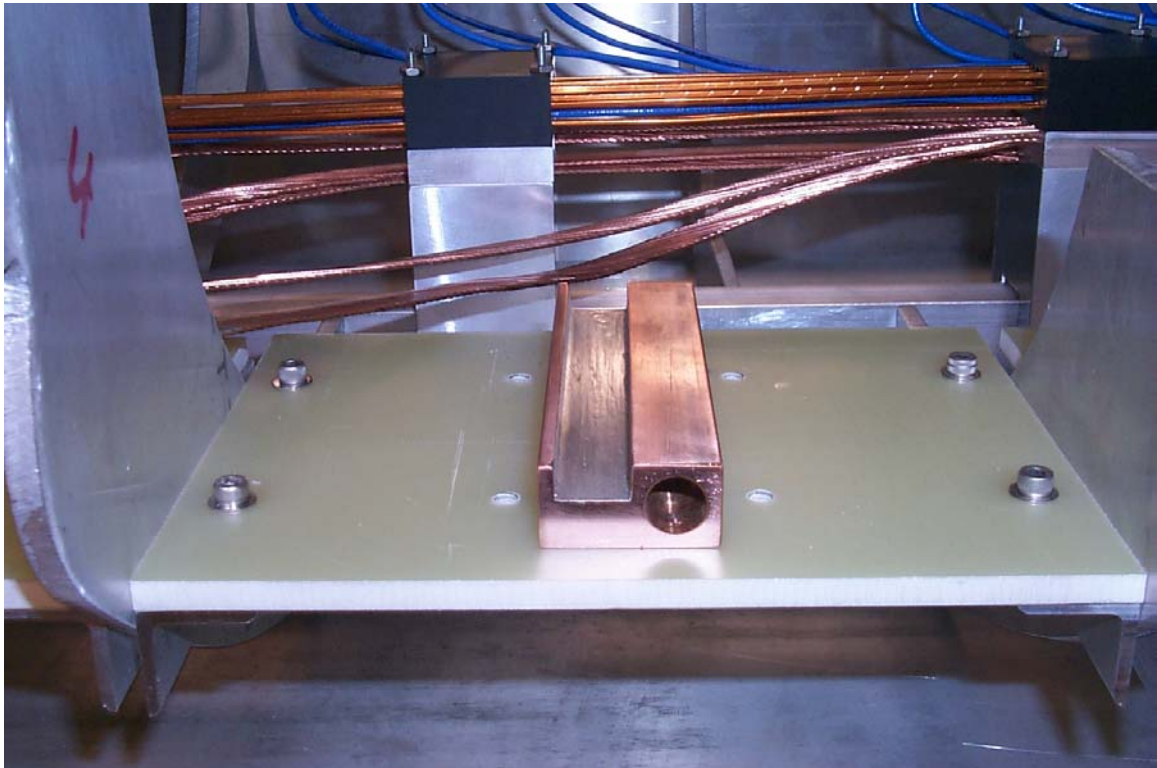


PHOTO #1

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2. Determine routing and bend radius for the cable. (Photo #2)

Note: the cable has a minimum bend radius of six inches; a bend radius less than six inches will cause a separation of the individual cable strands.

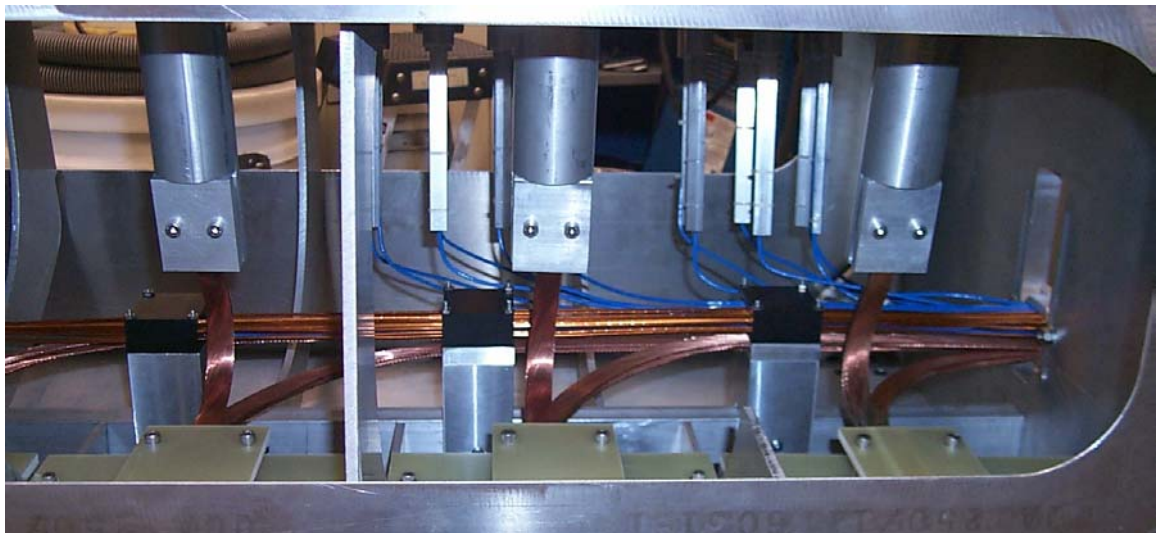


Photo #2

When routing cable and determining bend radius consideration should be made for the routing the cable through the cable looms. Cable looms should be assembled in the LHC IR Feed box prior to the cable routing procedure.

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3. Perform a trial layout with the four cables to be used in the splice. Verify that the correct cables are being used. Verify that the cable positions and orientations are correct so that the narrow edges of the keystone cables will be alternating in the solder splice box. Mark the cables for pre-tinning and cutting to correct length. (Photo #3) Care should be taken not to damage the Kapton insulation surrounding the cable.

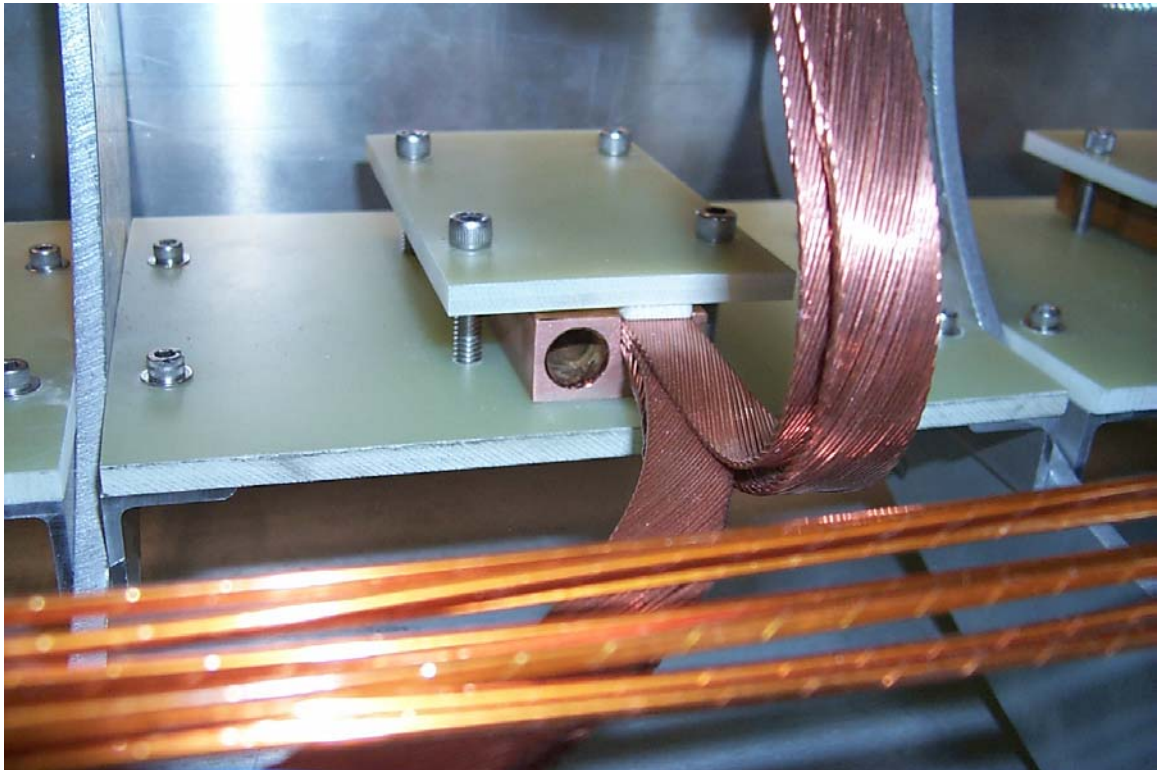


Photo #3

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4. Tin the cables. For maximum flexibility, tin the cables only the length of the solder box. Also, the cables from the lambda plug shall be tinned at a distance of 100 mm from the end of the splice block, where the voltage tap wires will be mounted.
5. Cut solder ribbon to correct length. Coat cables with flux. Assemble cables in the solder box, with pieces of solder ribbon between each pair of cables, as shown in Photos 4 thru 7.

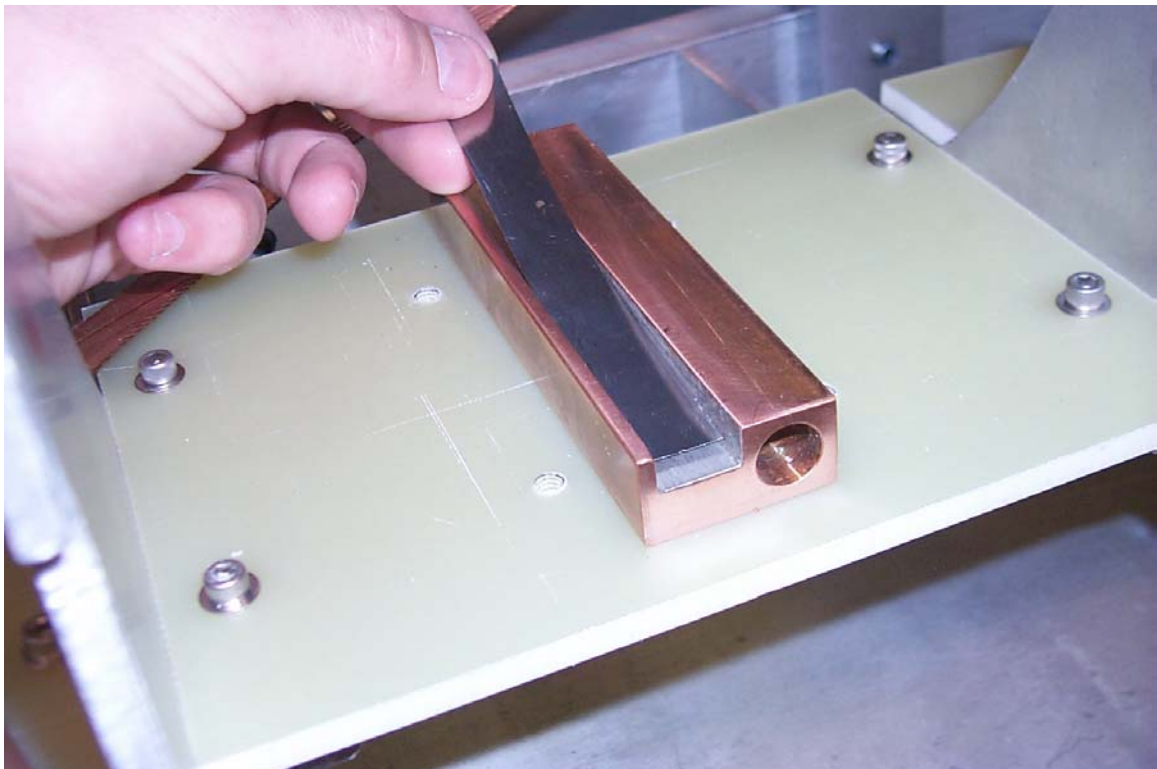


Photo #4

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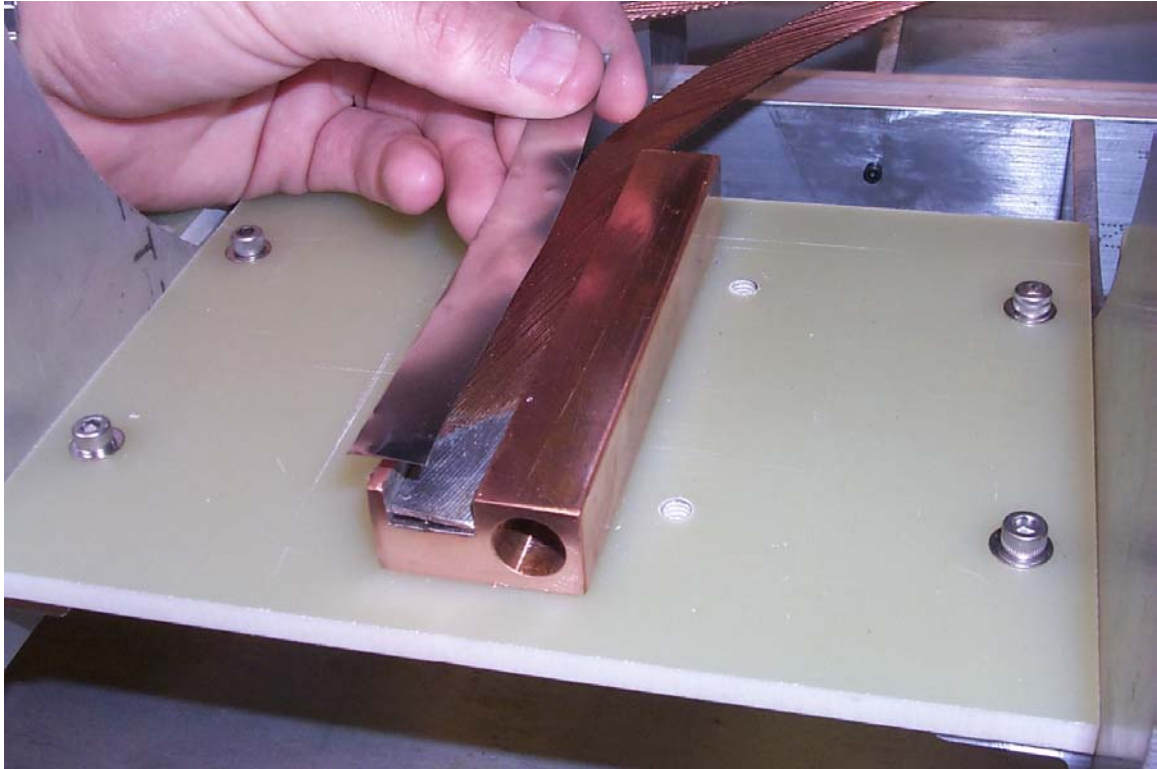


Photo #5

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Photo #6

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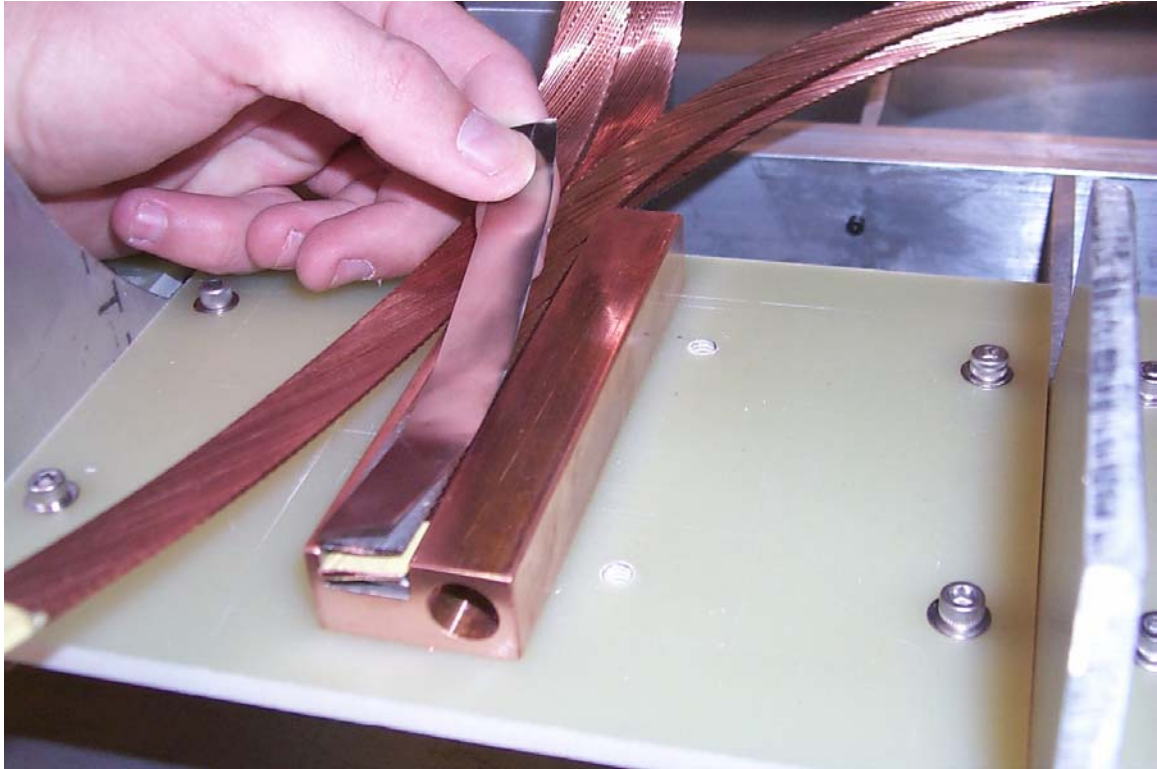


Photo #7

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6. Place the aluminum push block (Dwg. # 25I6673) into the groove over the top piece of conductor. Hold down and slide the G10-CR clamp plate (Dwg. # 25I6643) onto it. Use the hardware that is specified on the drawing. Start the four bolts and snug down. This will hold tension on the stack while soldering. (Photos #8 & #9)

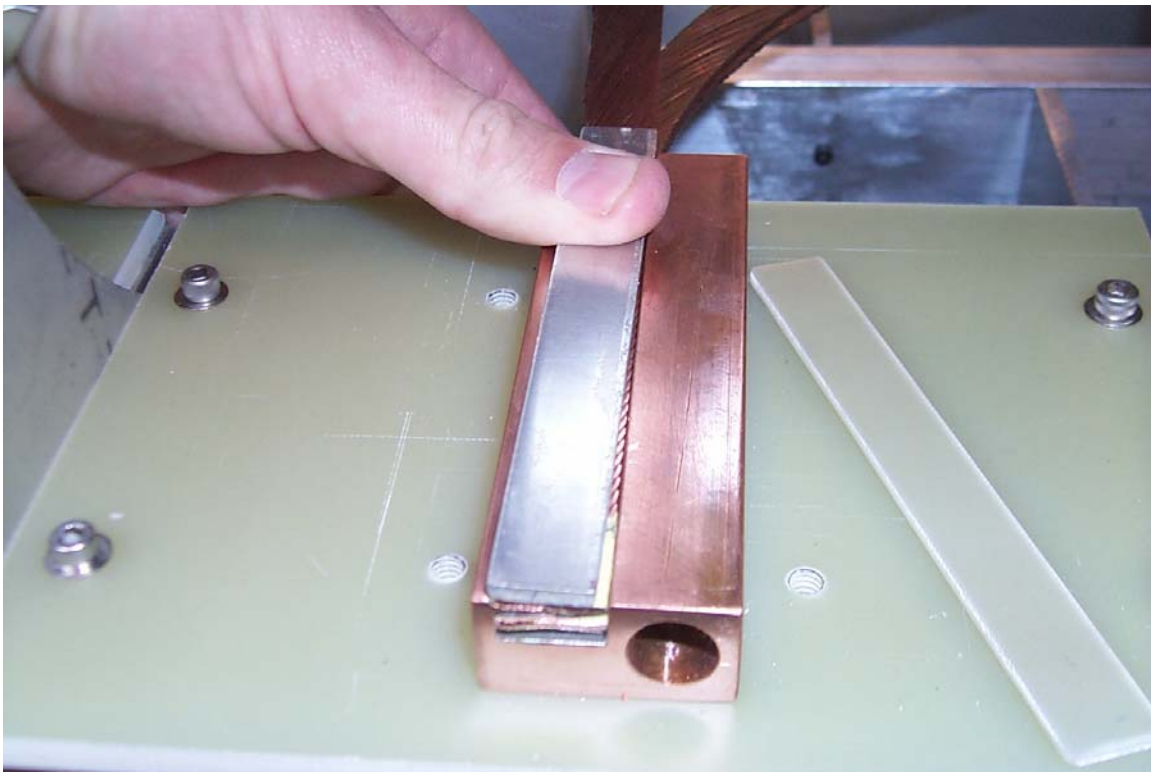


Photo #8

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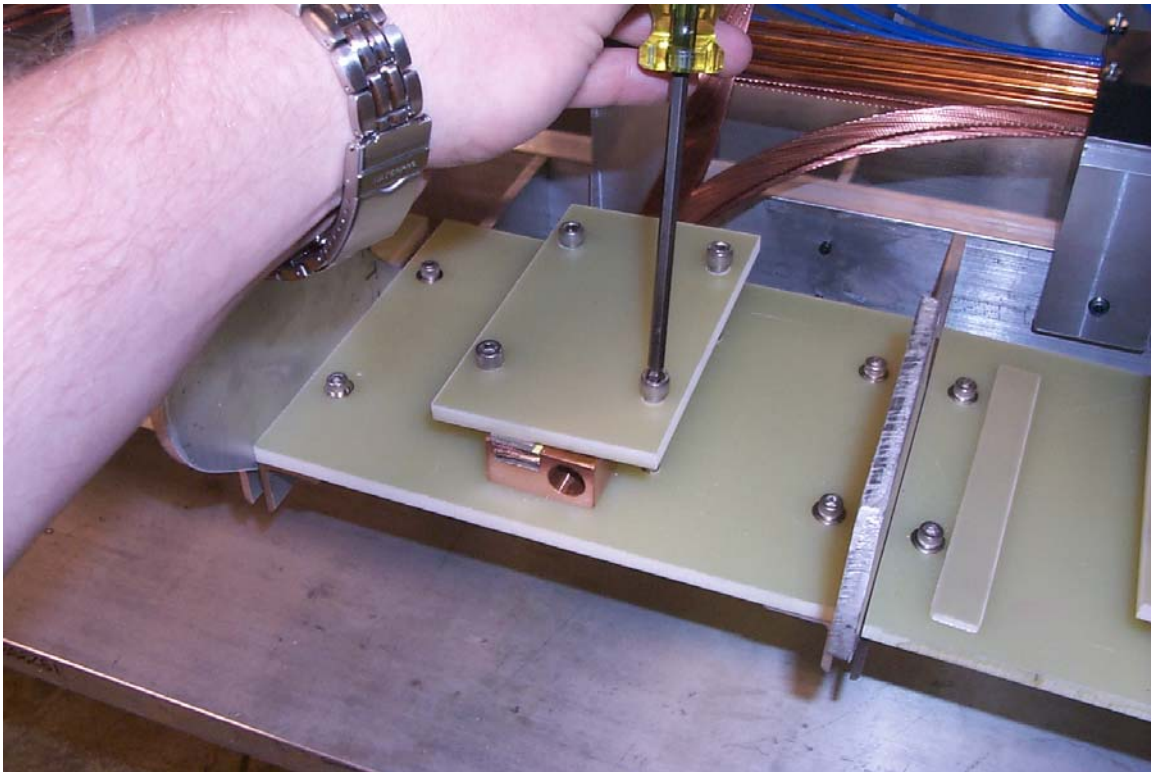


Photo #9

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7. Insert cartridge heater into holder. Plug the heaters into 120 VAC source. Use a Variac to control the voltage so as to not exceed 240C. Turn variac on and monitor the progress of heating the cables with the thermocouple in the holder and by observing when the solder melts. Do not allow the temperature to exceed 240 C. Feed in extra solder when solder reaches melting point. Tighten screws on solder fixture to insure that the excess solder is squeezed out of the joint. Keep feeding solder into the joint until the solder has solidified. (Photo #10)

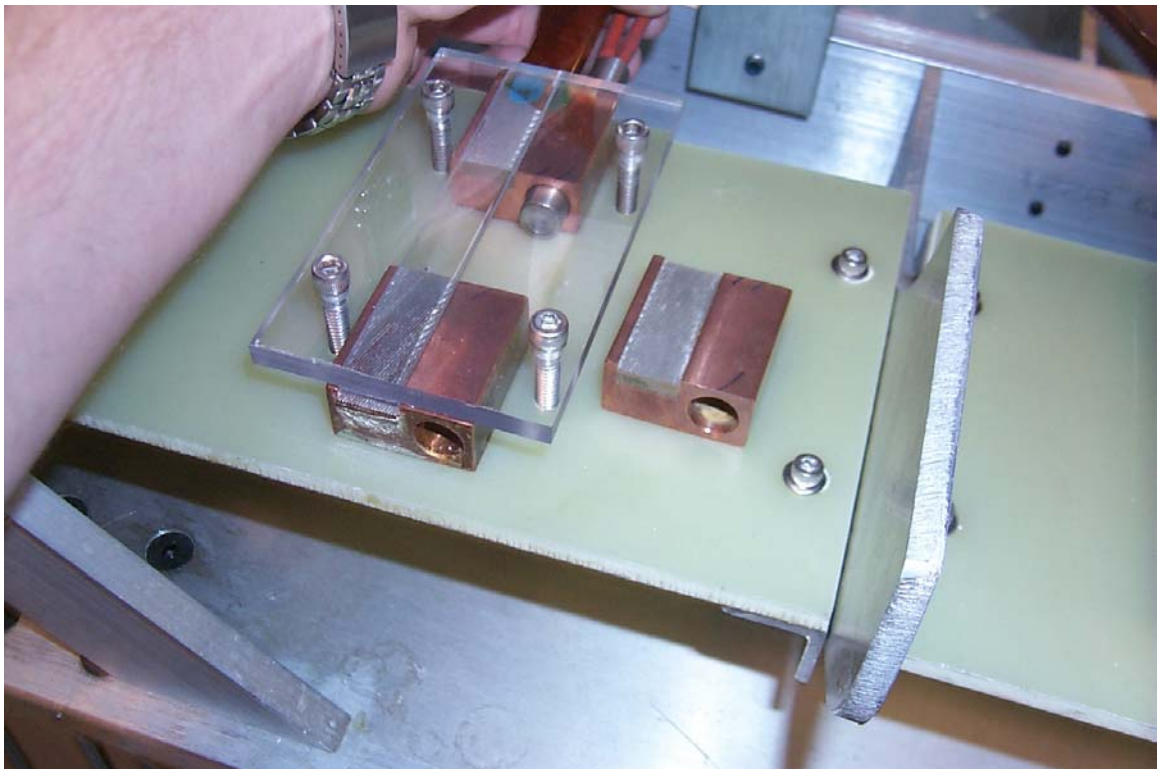


Photo #10

8. Install the voltage tap wire to the conductor. Make this joint upstream about 100 mm from the splice block.
9. After the joint cools, remove the clamping plate and push block.
10. Clean up the joint area with Scotchbrite and isopropyl alcohol to remove any residual flux and excess solder.

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11. Install the G10-CR pusher block (Dwg. # 25I6683) and clamping plate. Tighten up the four screws (Photo #11).

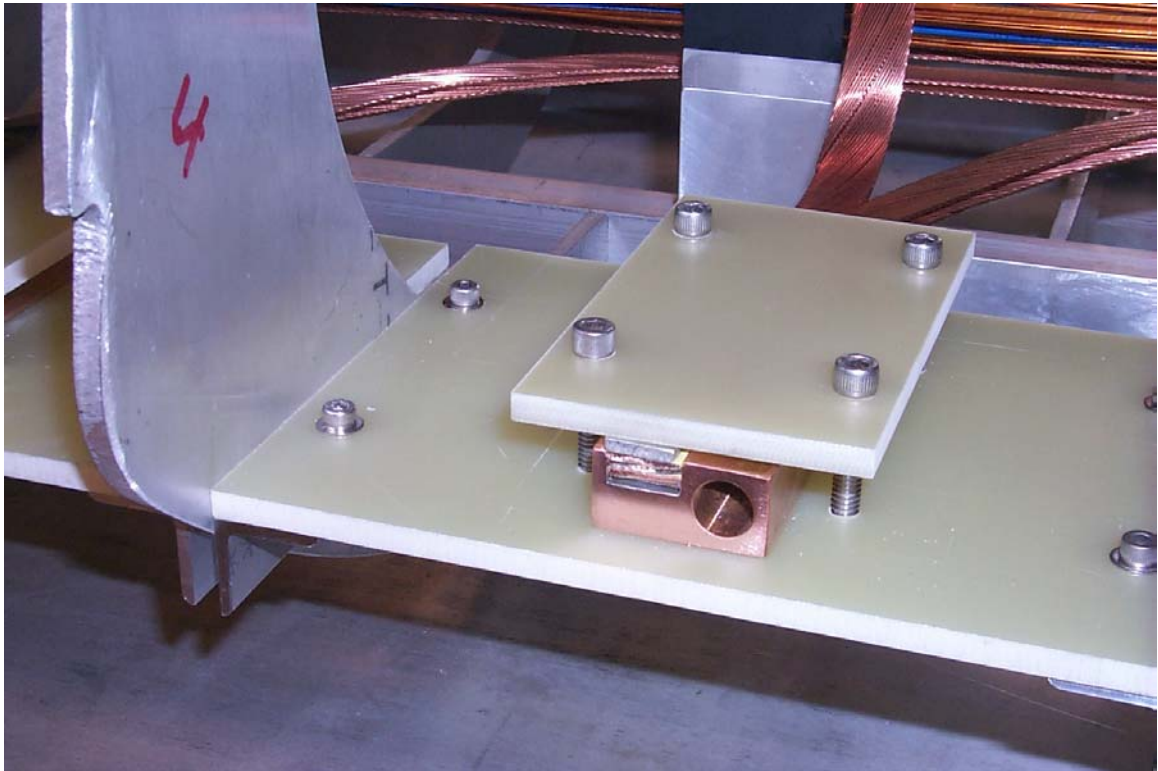


Photo #11

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Electrical Performance Test

After the splices are completed and the insulation applied, the high voltage performance shall be verified by performing a voltage stand-off test (referred to as a “hi-pot” test) following the procedure described below. The completed lead system shall be tested to 5000 volts, in a nitrogen atmosphere.

1. SCOPE:
This procedure describes the general Hi-Potting process to check the integrity of insulation between electrical components.
2. APPLICABLE DOCUMENTS:
 - a. LBNL Health and Safety Manual, PUB 3000, Chapter 8, “Electrical Safety”.
 - b. High Potter technical manual.
3. REQUIREMENTS:
 - 3.1 Equipment and Materials:
 - a. Hypotronics, Model 306B Hy-pot tester or Bertan Associate Inc. Bin Power Module Model 375X high voltage power supply or equivalent.
 - b. Grounding strap 1/6” X 7/16” Wide stranded wire or equivalent
 - 3.2 Safety Precautions:
 - a. Follow all applicable safety precautions called for in PUB-3000.
 - a1. Pub 3000 rates this operation as a Class 1B hazard (Low), high voltage very low current. The operation will be performed in a Mode 2 classification, (manipulative operations performed on non-energized system. Energized in close proximity to exposed components).
 - b. This test is to be conducted only by qualified technicians who have been trained in the proper use of the equipment and who are knowledgeable in the construction of these components.
 - c. When testing, insure the area is cordoned off and posted as “DANGER – HIGH VOLTAGE”.
 - d. Notify the supervisor or responsible person that High-potting will be performed.
 - e. When performing High Pot testing or when around high voltage and handling test leads it is a good practice to keep one hand in your pocket and keep a safe distance from energized components. Also keep other people away while conducting a high voltage tests.

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3.3 PROCEDURE:

3.3.1 Calibration Check:

- a. Disconnect all measuring instruments and any source of voltage.
- b. Ensure that the Hi-pot meter is off and discharge the D.C. OUT terminal with a ground lead.
- c. Use only the SHV test leads provided with the instrument. DO NOT remove the SHV Cable from these instruments. For the Hipotronics tester, plug the BLACK lead to the GROUND terminal and the RED lead to the D.C. OUT terminal. For the Bertan tester, connect the ground strap to the chassis case. Connect a DVM to the voltage monitor and a second DVM to the current monitor. Set the DVM to DC volts and the current monitor to mV. For the Bertan tester, the voltage monitor reads 10 volts = 10KV the current monitor reads 10V = 1mA
- d. Connect the GROUND cable or strap to Earth ground.
- e. Connect a 20 M Ω resistor across the GROUND and D.C. OUT terminals for either tester.
- f. Move the Hipotronics sensitivity knob to the maximum sensitivity. . The Bertan should be set to the 100 μ A scale
- g. Move the range switch to LOW (1-1.2 KV range) or the turn pot to zero voltage in the case of the Bertan.
- h. Turn the main power switch on and increase the voltage to 500 Volts. Note the current reading is 25 μ A. The Bertan should read $\frac{1}{4}$ of scale on the 100 μ A setting. If the meter does not read these values the Hi-pot tester is not working correctly. Turn the tester off and reduce the voltage control knob to zero. Inform the Cognizant Supervisor. If the reading is correct raise the voltage towards 1000V and verify the trip point is approximately 50 μ A. The Bertan meter will trip at 80% full scale or 80 μ A. Accordingly, the voltage for the Bertan will trip at approximately 1600 V.
- i. Repeat the test if necessary to verify a trip point of less than 50 μ A
- j. Record the trip point on the Hi-pot record book.
- k. Turn the Hi-pot off and discharge it by touching the grounding lead to the D.C. OUT terminal and resistor.
- l. Disconnect the resistor.

3.3.2 HI-POT TEST:

- a. Ground test point prior to connecting the instruments to discharge any stored energy in the device to be tested. Be aware that high pot test can charge up capacitance in the system. Although the calculated energy in these magnets is less than 5 joules, the stored energy in any system is a concern and the primary source of hazard. If in doubt the capacitance can be measured and should be less than 10 μ F at 1000V.
- b. Connect the (+) SHV lead to the magnet or magnet component.
- c. Connect the ground strap to EARTH ground, to the ground potential of the respective component, and to the chassis case or ground terminal.
- d. Move the sensitivity knob to the maximum setting. For the Bertan the sensitivity setting is 1 μ A.
- e. Move the Voltage control setting to low and the control knob to the minimum position.

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- f. Move the current meter setting to X100 for the Hipotronics.
 - g. Turn the High Pot tester power switch on. Turn the VOLTAGE control knob very slowly to raise the voltage until 1000 V (1KV) has been reached. Switch to the high setting and continue to increase the voltage until the specified voltage is reached. The reading should be less than 10 μ A.
 - h. Record the reading, inform the cognizant supervisor if any reading is greater than 10 μ A.
 - m. A fault in the insulation or in the test connection will cause the meter to trip off. Turn the Hi-pot tester power switch off, turn the voltage control to the minimum position, and then discharge the component and tester by touching the Ground cable to the positive terminal connection. You can now disconnect the lead.
 - n. DO NOT REPEAT THIS TEST UNNECESSARILY AS IT MAY CAUSE A CARBON TRACK OR ARC POINT DAMAGE TO A COMPONENT.